Research Article

The evaluation of appropriate office layout design with MCDM techniques

Ergün Eraslan[1] · İlknur Güneşli[1] · Wael Khatib[1]

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Abstract
Office layout design is pertinent in terms of ergonomics to obtain a sustainable workspace. There are five workplace evaluation parameters to be considered, namely successiveness, work within the limits of biological ability, work within the limits of sustainable work performance, work within the social limits, and work fulfilling psychological expectations and individual satisfaction of being able to exercise all abilities. In ergonomics, job satisfaction is an essential matter for an employee to perform a task productively. Since the office design mostly affects the worker's performance and health at the same time, it is a requirement to create sustainable workplace. Multi-criteria decision-making methods are not only broadly used in different fields and disciplines, but are also considered to be an essential field in ergonomics. This paper aimed to propose a method in order to analyze and compare the office layout design with the methods of analytical hierarchy process, elimination and choice translating reality, and permutation method. The criteria in this paper are established in a hierarchical order by employing these methods. All in all, office alternatives are compared, and the overall results are examined.

Keywords Office ergonomics · Multi-criteria decision-making · AHP · ELECTRE · Permutation method

1 Introduction

Ergonomics is basically defined as environment and work (machine)–human interaction. In ergonomics, optimization study of designs for human use and work-life conditions are examined. The workplace is rearranged with respect to both the working space and the work itself, which resonates with the science of ergonomics. When the working environment is in accordance with the anatomical, physiological, psychological characteristics and capacity of the person performing the work, the conformity is achieved between the work and the human being, resulting in the highest efficiency with the least fatigue [1]. Thus, ergonomics deals with many factors such as noise, vibration, thermal comfort, lighting, radiation, and high and low pressure [2].

In work systems, the ergonomic requirements are basically summarized as: the office equipment that comprises of monitor/screen, the keyboard, the desk/work surface, and the seat. It is also essential to have a comfortable and upright sitting position to attenuate the pain around the neck, shoulders, lower back, arms, wrists, legs, and other parts of the body [3]. In an office environment, the risk of developing musculoskeletal disorders (MSDs) among workers is higher due to continuous mouse and keyboard use, high muscle tension, and previous MSDs around the neck and the shoulder [4]. Therefore, repetitive strain injury (RSI) can occur in the long run [5].

The environmental conditions comprising of requirements for the workspace, the lighting, the noise, the thermal environment and the static electricity, the software that comprise of usability-related issues, and the work

✉ İlknur Güneşli, ilknurgunesli@gmail.com | [1]Industrial Engineering Department, Faculty of Engineering and Natural Sciences, Ankara Yıldırım Beyazıt University, Ankara, Turkey.

organization, which comprise of macro-ergonomics issues, are also included [6]. Moreover, the ill-calculated issues that sustain workspace environment could also lead to health issues such as tendonitis, carpal tunnel syndrome, or degenerated spinal diseases due to ruptured or bulging disk around the neck or the back. These issues should be considered in order to meet a healthy requirement and help sustain a compatible placement and individual workstations. Thus, some of the requirements are deemed to be heavily dependent on each other. For instance, there should be no annoying reflections or glare in the working area, appropriate lighting that conforms to the task's needs, a facilitated cooperation between the personnel, a conformance between the organizational structure and the placement of the workstations, no annoying hot or cold draughts in the workplace, and ease of access to elements such as windows, cooling/heating devices, etc., for manipulation and maintenance purposes. Besides, the lighting should be uniform throughout the employees' visual field [6].

When selecting a facility layout, strategic perspective should be considered to achieve the highest performance in the system with respect to cost and time [7]. Thus, the best layout design is selected from various proposed alternatives in order to handle an efficient process facility and improved productivity of the workers. It is indicated that only a few studies deal with the effects of automation-induced factors such as technical problems, poor usability, poor situation awareness, and qualification requirements on subjective experience [8]. Multi-criteria decision-making (MCDM) methods will not only assist users to make better selection(s), but will also help them deal with making numerous and conflicting evaluation(s) [9]. Since the selection criteria could not have the same criticality, the final importance of criteria could be adapted with them.

In the literature, many methods have been proposed to analyze the data of a decision matrix and rank the alternatives. Under many occasions, different MCDM methods could yield different answers to exactly the same problem [10]. Since the various answers are given to the same issues, the study is conducted using three different methods in order to pinpoint applicable ones. There could seem existing alternatives or the possible results before the office design process. For instance, the organizational structure or the departments can be changeable matters when we consider the whole organization. The activities also need to be checked whether they are appropriate for the organization or not. Because of that reason, it is aimed to clarify whether these findings can be generalized to real working conditions in this study.

This paper is organized as follows: Section 2 provides an overview of related studies developed in the literature. In this section, analytical hierarchy process (AHP) technique which is suitable for not only to identify the weights of criteria by the field experts but also to compare the alternatives is given. Elimination and choice translating reality (ELECTRE) is used to rank the alternatives and permutation methods are briefly explained. The AHP technique and other MCDM methods are available in the studies conducted in the literature, but in this study, the problem is handled one by one with AHP, ELECTRE, and permutation methods, and comparisons are made with these different methods. In this study, the AHP results are checked whether this method is applicable or not. In addition, the permutation method was used for the first time in studies in this area. Section 3 covers the application of a comprehensive methodology which is never explored in the previous researches with the use of AHP, ELECTRE, and permutation methods. In Sect. 4, the results of the study and the comparisons of the selected methodologies to evaluate alternative facilities are discussed. It is also pointed out the necessary improvements in future works.

2 Literature review

Many methods have been proposed to analyze the data of a decision matrix and rank the alternatives. Often times different MCDM methods may yield different answers for exactly the same problem [10]. Some of MCDM models deal with what is known as "outranking relations" in order to rank a set of different alternatives. AHP method is considered as a very suitable tool to determine the criteria among other alternatives when field experts and users are involved. A prominent role in this group is played by the ELECTRE method and its derivatives. Permutation method is also one of MCDM methods that calculate all available combinations of the given alternatives in order to reach the best order of them. Since this method has to calculate all of possible combinations of the alternatives to solve the problem, it could be a NP-hard problem in large number of alternatives and criteria [11].

2.1 Related works

Multi-Criteria Decision Analysis (MCDA) which is also called as MCDM methods are broadly used in different fields and disciplines. While these are taken into account as multifarious criteria, it helps to support a decision maker in order to decide the most preferable one from various possible options. The criteria could also specify the quality of variants when all options are permissible, and the issue is to choose the best one subjectively [12]. Ergonomic requirements are indicated when concerned with the design of computerized offices [6]. According to these requirements, the office equipment, the environmental conditions, the software, and the work organization are addressed as four main elements of the work system. An alternative approach to select a suitable type of layout using AHP method is presented [13].

In most facility layout selection problems, multiple attributes are considered in the selection criteria, which makes the selection process a MCDM problem [7]. In Table 1, some of the papers are examined with the applications of MCDM methods to find the best alternative among several layout designs. For instance, an analysis of AHP and fuzzy AHP for the lean waste identification model is presented [14]. The underlying assumption in AHP is having independent criteria, in which the problem can be structured as a hierarchy that gives the decision makers a clear understanding of the problem [15]. The relationship between office layout features and job satisfaction, and the position of organizational culture in mediating their relationship, is discussed [16]. An approach for prioritizing and scoring the measures of the ergonomic checkpoints using analytic network process (ANP) and Fuzzy Decision Making Trial and Evaluation Laboratory (fuzzy DEMATEL) methods is presented [17]. There is an analysis of the criteria that industrial engineer count on for selecting working area after graduating, using fuzzy analytic network process (FANP) method [18]. A new workshop layout is evaluated and selected from a set of alternatives using AHP and TOPSIS methods [19].

2.2 The analytic hierarchy process method

AHP method is one of MCDM methods that was originally developed by Prof. Thomas L. Saaty [15]. This method derives ratio scales from discrete and continuous comparisons that are paired. It is a very effective tool to deal with complex decision-making problems that reduce complex decisions to series of pairwise comparisons and then synthesize the result. Modeling an AHP problem needs a network or hierarchy structure to pairwise comparisons and establish relations within the structure (as a matrix). This gives a weight for each element within a level of the hierarchy (the higher the weight, the more important the corresponding criterion) and also gives a consistency ratio (useful for checking the consistency of the data).

Saaty has developed the following steps for AHP [15]:

1. *Define the unstructured problem*: Stating the objectives and outcomes of the problem.
2. *Define the criteria and alternatives*: Preparing a full list of all possible alternatives defining the alternatives that need to be evaluated, which can be different criteria of product features to evaluate the solution.
3. Define the priority among criteria using pairwise comparison: Using pairwise comparison in which the 1–9 scale is demonstrated in Table 2 helps creating a matrix by assigning values according to the importance intensity of the alternatives.
4. Estimate the relative weights of the decision elements
5. *Check the consistency ratio (CR)*: Once judgments have been entered, it is necessary to check that they are consistent. The AHP method incorporates an effective technique for checking the consistency of the evaluations made by the decision maker when building each of the pairwise comparison matrices involved in the process. The technique relies on the computation of a suitable Consistency Index (CI) and Random Index (RI) which are used in the level of reliability of the same assessment made repeatedly. If $CR < 0.1$, the judgments of the experts are acceptable. Otherwise, the decision maker should revise the judgment(s) and improve the evaluation process(es).
6. *Get the final weights*: We need to calculate the overall priority (also called final priority) for each alternative; that is, priorities that take into account not only our preference of alternatives for each criterion but also the fact that each criterion has a different weight.

2.3 The elimination and choice translating reality (ELECTRE) method

ELECTRE method is presented by B. Roy in 1960s, and it was connected to numerous fields in order to tackle various multi-measure related issues [29]. The ELECTRE method is used to analyze the data of a decision matrix to rank a set of alternatives. ELECTRE method reflects the dominance of relations among alternatives by outranking relations. It is possible that alternatives can be compared by these outranking relations built in this way. In ELECTRE method, concordance and discordance indexes are two types of indices pairwise comparison between alternatives in ELECTRE I. Steps of ELECTRE I are demonstrated as [29]:

1. Normalization of matrix and weighted matrix.
2. Ascertainment of concordance and discordance interval sets: The concordance interval set is applied to describe the dominance query and the discordance interval set is opposite of it.
3. Calculation of the concordance interval matrix.
4. Determination the concordance index matrix.
5. Determination the discordance index matrix.
6. Calculation the net superior and inferior value.

2.4 Permutation method

Permutation method is one of MCDM methods that calculate all available combinations of the given alternatives in order to reach the best order of them. The outranking

Table 1 The applications of MCDM methods in ergonomics

No	Paper name	Author(s)	Field of study
1.	Ranking of MUDA using AHP and fuzzy AHP algorithm [14]	Gnanavelbabu and Arunagiri (2018)	It is presented analysis of AHP and fuzzy AHP for the lean waste identification model.
2.	The influence of office layout features on employee perception of organizational culture [16]	Zerella et al. (2017)	The relationship between office layout features and job satisfaction, and the position of organizational culture in mediating their relationship is found.
3.	Prioritizing the ILO/IEA ergonomic checkpoints' measures; a study in an assembly and packaging industry [17]	Ahmadi et al. (2017)	It is presented an approach for prioritizing and scoring the measures of the ergonomic checkpoints using analytic network process (ANP) and Fuzzy Decision Making Trial and Evaluation Laboratory (fuzzy DEMATEL) methods.
4.	Multi-criteria decision making for the selection of a performant manual workshop layout: a case study [19]	Besbes et al. (2017)	A new workshop layout from a set of alternatives using AHP and TOPSIS methods is evaluated and selected.
5.	Incorporating the human factor within manufacturing dynamics [20]	Fruggiero et al. (2016)	A model that includes all the principals and factors to incorporate human factors with system dynamics is proposed.
6.	Measuring operational performance of OSH management system—A demonstration of AHP-based selection of leading key performance indicators [21]	Podgórski (2015)	AHP method for selecting leading key performance indicators (KPIs) for measuring OSH MS operational performance is used.
7.	Kano model and QFD integration approach for Ergonomic Design Improvement [22]	Hashim and Dawal (2012)	The school workshop's workstation design for adolescent in terms of ergonomic and users need by using joining methods of Kano model and quality function deployment is improved.
8.	Selection of working area for industrial engineering students [18]	Rouyendegh and Can (2012)	The criteria industrial engineer count on for selecting working area after graduating, using fuzzy analytic network process (FANP) method is analyzed.
9.	Application of a trapezoidal fuzzy AHP method for work safety evaluation and early warning rating of hot and humid environments [23]	Zheng et al. (2012)	The work safety in hot and humid environments using a proposed trapezoidal fuzzy AHP method to demonstrate the engineering practicability and effectiveness of this method in extreme environment evaluation is evaluated.
10.	A review of applications of analytic hierarchy process in operations management [24]	Subramanian and Ramanathan (2012)	The gaps in the literature of analytic hierarchy process (AHP) method and suggesting possible future studies and applications to fill the gaps in the literature is found.
11.	A fuzzy analytic hierarchy processing decision support system to analyze occupational menace forecasting the spawning of [25] shoulder and neck pain	Padma and Balasubramanie (2011)	Fuzzy analytic hierarchy process as an evaluation tool to measure the significance of the risk factors in each occupation is applied. This will help healthcare organizations to spot the appropriate occupations that have high risk for the spawning shoulder and neck pain (SNP) occurrence
12.	Office layout affecting privacy, interaction, and acoustic quality in LEED-certified buildings [26]	Lee (2010)	A study about work satisfaction and workers performance concerning issues as privacy, interaction and acoustic quality in personal workspaces between five office types in LEED-certification buildings is conducted.

Table 1 (continued)

No	Paper name	Author(s)	Field of study
13.	Developing a fuzzy analytic hierarchy process (AHP) model for behavior-based safety management [27]	Dağdeviren and Yüksel (2008)	The work safety issue and proposing a fuzzy AHP approach to determine the level of faulty behavior risk (FBR) in work systems is studied.
14.	Supporting the design of office layout meeting ergonomics requirements [6]	Margaritis and Marmaras (2007)	A method to support the ergonomics layout design of individual workstations in a given building is proposed.
15.	User-oriented method for selecting workstation components [28]	Fogliatto and Guimaraes (2004)	A method to provide workers a customized work station to their personal needs yet ergonomically consistent is proposed.
16.	Office Ergonomics [2]	Kroemer and Kroemer (2001)	The information about office ergonomics in general is provided.

methodology constitutes one of the most efficient approaches in MCDM. It has been applied in various real-world cases. The permutation method is a classical outranking model, which generalizes Jacquet–Lagreze's permutation method and is based on the pairwise criterion comparison of the alternatives [30]. It is also considered as a NP-hard problem in large number of alternatives and criteria [3] because it calculates all of possible combinations of the alternatives to solve the problem. This method allows dealing with both qualitative and quantitative data as well as with data expressed in words (verbal defined data) and allows to define the most appropriate order of alternatives [31]. In this method, the benefit (*P* value) of each possible order of the alternatives is calculated, and the highest one is picked as the correct order. If there are *N!* orders for each *N* alternatives, the complexity of the method is *N!*. The *P* values of the current order of the alternatives are calculated as below:

Step 1 Assigning matrix *M* for the current order of the alternatives

Step 2 Forming the matrix of pair comparison in accordance with the decision matrix for each ranking, ($A_i \ldots A_j$). *Pij* is the total of the weights of attributes in which the alternative of *i* is higher or equal to *j* option in this matrix.

Step 3 Calculating the score of matrix M that its quantity is equal to the difference of the total figures over the main diameter from the total figures below the main diameter. These steps must be repeated for each possible order of alternative and the order with the highest *P* value that could generate the correct answer for the problem [11].

3 Application of the MCDM methods to evaluate appropriate office layout

According to our research; job satisfaction, physical environment and environmental conditions are essential for employees to be efficient at a workplace. When they are satisfied with the physical environment and environmental conditions, they work more effectively. It is indicated that job satisfaction can be affected by the office layout, which particularly can influence the behavior of workers resulting in pleasure and help reinforce positive state while performing a task [3]. Thus, it is also found that criteria which are mostly considered by many researches in the office layout design are summarized as follows: working safety (WS), dust, smell, light, working position (WP), noise, working area (WA), position of tools (PoT), and position of materials (PoM) for this study. All in all, the problem is established by demonstrating AHP, ELECTRE and permutation

Table 2 The 1–9 scale for pairwise comparisons in AHP method [15]

Numerical rating	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment slightly favor one over another
5	Strong importance of one over another	Experience and judgment strongly favor one over another
7	Very strong importance of one over another	Activity is strongly favored and its dominance is demonstrated in practice
9	Extreme importance of one over another	Importance of one over another affirmed on the highest possible order
2, 4, 6, 8	Intermediate values	Used to represent compromise between the priorities listed above

methods and then, three office alternatives are compared and the overall results are examined, respectively.

3.1 Application of AHP method

Our study has been conducted at United Nations High Commissioner for Refugees (UNHCR) office for Hotline and Translating department. A questionnaire was conducted in reliance with the identified factors and their criteria, and ranked by experts at the office using the AHP pairwise comparisons scale. Then, a hierarchical model which is shown in Fig. 1 was defining the relationship between the factors and the alternatives was constructed. The criteria were obtained from the literature as mentioned above then categorized for the office layout design under the following three main criteria namely working safety, comfort at work, and easiness of motion [32]. The hierarchy is established as a holistic perspective that deals with not only the physical capabilities of a person but also the working environment. For instance, the working area, position of tools, and the position of materials are considered as easiness of motion and light, working position, and noise are handled as comfort of work. Six office experts participated in the conducted survey. Three alternatives for an office layout were developed as shown in Fig. 2. The data were processed using AHP steps that were previously mentioned.

After obtaining these ratings from each of the experts, the average ratings were calculated and were formed to create the pairwise comparison matrices. Then, the pairwise comparison matrices are normalized for all alternatives, which are demonstrated in Table 3 below.

Using these weights, the priorities on distributive modes were obtained according to their criteria that are demonstrated in Table 4. All in all, according to AHP method, Office C is the best alternative to be chosen among three office alternatives.

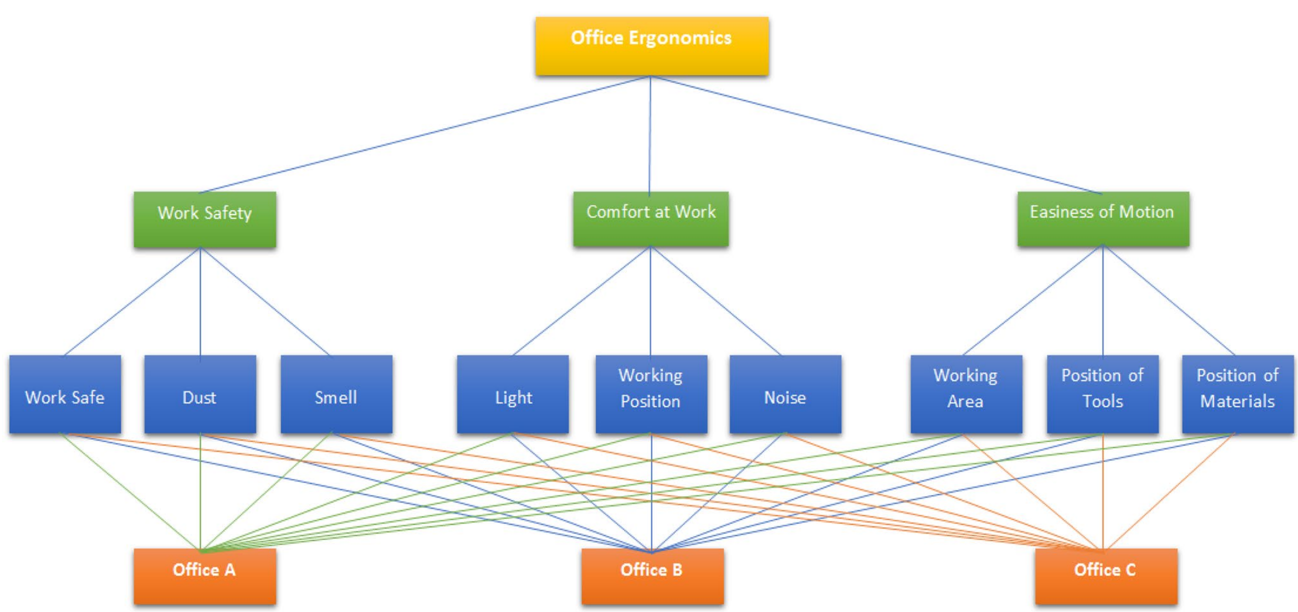

Fig. 1 The hierarchical model of the problem [32]

Fig. 2 The office layout alternatives

Table 3 Normalized pairwise comparison matrices for all alternatives

	Criteria								
	Working safety			Comfort at work			Easiness of motion		
Alternatives	WS	AHP		Light	AHP		WA	AHP	
	A	0.364	36.4%	A	0.391	39.1%	A	0.243	24.3%
	B	0.324	32.4%	B	0.311	31.1%	B	0.339	33.9%
	C	0.312	31.2%	C	0.298	29.8%	C	0.418	41.8%
	Dust	AHP		WP	AHP		PoT	AHP	
	A	0.392	39.2%	A	0.315	31.5%	A	0.301	30.1%
	B	0.310	31.0%	B	0.349	34.9%	B	0.333	33.3%
	C	0.298	29.8%	C	0.336	33.6%	C	0.366	36.6%
	Smell	AHP		Noise	AHP		PoM	AHP	
	A	0.391	39.1%	A	0.355	35.5%	A	0.206	20.6%
	B	0.311	31.1%	B	0.329	32.9%	B	0.379	37.9%
	C	0.298	29.8%	C	0.316	31.6%	C	0.415	41.5%

Table 4 The priorities on distributive mode according to AHP method

	WS	Dust	Smell	Light	WP	Noise	WA	PoT	PoM	Distributive mode
A	0.364	0.392	0.391	0.391	0.315	0.355	0.243	0.301	0.206	2.958
B	0.324	0.310	0.311	0.311	0.349	0.329	0.339	0.333	0.379	2.985
C	0.312	0.298	0.298	0.298	0.336	0.316	0.418	0.366	0.415	3.057

3.2 Application of ELECTRE method

The second phase of this is applying ELECTRE method to see whether it is applicable in the types of layout design problems, which was never explored as observed in literature review. A second questionnaire was conducted according to the identified factors and their criteria, and was later ranked by six experts at the office using the same scale applied in AHP pairwise comparisons ranking. Six experts rated the criteria in each of the alternatives according to their importance. After obtaining these ratings from each of the experts, the average ratings were calculated for the criteria in each of the alternatives that are shown in Table 5 below. Pairwise comparison matrix for ELECTRE method is formed by using the average criteria and the weights calculated using AHP method that is demonstrated in Table 6.

ELECTRE method was applied using XLSTAT 2019 software to obtain concordance matrix, discordance matrix, outranking matrix and ranking table. Concordance

Table 5 Average ratings for the criteria in each of the alternatives for ELECTRE method

Office A	Rate	Office B	Rate	Office C	Rate
Work Safe	6	Work Safe	6	Work Safe	8
Dust	6	Dust	6	Dust	7
Smell	5	Smell	6	Smell	7
Light	7	Light	8	Light	7
Working Position	6	Working Position	7	Working Position	6
Noise	7	Noise	7	Noise	6
Working Area	5	Working Area	5	Working Area	6
Position of Tools	7	Position of Tools	7	Position of Tools	8
Position of Materials	8	Position of Materials	6	Position of Materials	9

Table 6 Pairwise comparison matrix for ELECTRE method

Criteria	A	B	C	Criteria	Weights
Work Safe	6	6	8	Work Safe	0.106
Dust	6	6	7	Dust	0.114
Smell	5	6	7	Smell	0.114
Light	7	8	7	Light	0.114
Working Position	6	7	6	Working Position	0.101
Noise	7	7	6	Noise	0.103
Working Area	5	5	6	Working Area	0.121
Position of Tools	7	7	8	Position of Tools	0.106
Position of Materials	8	6	9	Position of Materials	0.121

matrix helps indicate similarities between the alternatives; nevertheless, discordance matrix helps show the distance between them.

As it can be seen in the ranking table in Table 7, all alternatives got the same rank which means the three of them are of equal importance according to ELECTRE method. According to our observation, the reason for this is the ranking numbers in the survey as they were too close to each other. ELECTRE was not able to prioritize any of the alternatives, which makes it inefficient for this case study.

Where the concordance matrix shows the similarities between the alternatives and discordance matrix shows the distance between them. As it can be seen in the ranking table, all alternatives got the same ranking, which means the three of them are of equal importance according to ELECTRE method. According to our observation, the reason for this is the ranking numbers in the survey as they were too close to each other. ELECTRE was not able to prioritize any of the alternatives, which makes it inefficient for this case study.

3.3 Application of permutation method

Up to our knowledge, no research has been found on the application of permutation method to facility layout selection which will be discussed in this paper. Multiple independent and dependent criteria, both qualitative and quantitative, are considered to evaluate alternative facilities [7]. In our previous study, AHP and ELECTRE methods are applied to calculate the weightage of the criteria which are given in Table 8 below [33]. Thus, it is aimed to apply permutation method for this study whether this method is applicable or not. When applying this MCDM method, all permutations of alternatives according to their preference probability are checked and compared among themselves

Table 7 Concordance matrix, discordance matrix, outranking matrix, and ranking table

Concordance matrix

a/b	A	B	C
A	1.000	0.773	0.897
B	0.462	1.000	0.682
C	0.318	0.318	1.000

Discordance Matrix

a/b	A	B	C
A	0.000	0.714	0.643
B	0.571	0.000	1.000
C	0.286	0.714	0.000

Outranking matrix

a/b	A	B	C
A	0	0	0
B	0	0	0
C	0	0	0

Ranking table

Action	Rank
A	2
B	2
C	2

Table 8 Weightage of the criteria

	WS	Dust	Smell	Light	WP	Noise	WA	PoT	PoM
Office A	8	7	8	8	5	6	4	5	3
Office B	9	7	8	8	7	7	7	7	8
Office C	9	7	8	8	7	7	9	8	8
Weightage	0.106	0.114	0.114	0.114	0.101	0.103	0.121	0.106	0.121

Table 9 The matrix of pair comparison in accordance with the decision matrix for each ranking

p1	Office A	Office B	Office C	p4	Office C	Office B	Office A
Office A	1.000	0.341	0.341	Office C	1.000	1.000	1.000
Office B	1.000	1.000	0.772	Office B	0.772	1.000	1.000
Office C	1.000	1.000	1.000	Office A	0.341	0.341	1.000
p2	Office A	Office C	Office B	p5	Office B	Office C	Office A
Office A	1.000	0.341	0.341	Office B	1.000	1.000	1.000
Office C	1.000	1.000	1.000	Office C	1.000	1.000	1.000
Office B	1.000	0.772	1.000	Office A	0.341	0.341	1.000
p3	Office B	Office A	Office C	p6	Office C	Office A	Office B
Office B	1.000	1.000	0.772	Office C	1.000	1.000	1.000
Office A	0.341	1.000	0.341	Office A	0.341	1.000	0.341
Office C	1.000	1.000	1.000	Office B	0.772	1.000	1.000

Table 10 P values for each possible alternative orders

p1	A-B-C	− 1.545
p2	A-C-B	− 1.090
p3	B-A-C	− 0.228
p4	C-B-A	1.546
p5	B-C-A	1.318
p6	C-A-B	0.228

[31]. Then, the matrix of pair comparison in accordance with the decision matrix for each ranking is given in Table 9. Since the best concordant ordering is having the largest value of evaluation criterion [9], P values for each possible alternative orders are calculated and the ranking is constructed as office C, office B, and office A as the highest value with 1.546 that are given in Table 10.

4 Conclusion

In previous sections, the methods and the applications of the MCDM methods in order to evaluate appropriate office layout are given. This paper contributes to obtain sustainable work at the office workplace by proposing a methodology in order to analyze and compare the office layout design using AHP, ELECTRE, and permutation methods. Furthermore, this study aims to clarify whether these findings can be generalized to real working conditions. The criteria that are conducted for the study are classified as workspace safety, dust, smell, light, working position, noise, working area, position of tools and position of materials weighed in both methods in this study. A hierarchical structure is established to prevent cumulative trauma positions with random problems that address work safety and physical risk factors for the first time in the literature.

The reason why the AHP, ELECTRE, and permutation methods are used in the article is that these methods have a solid and appropriate mathematical background and a holistic study is conducted. Thus, this paper contributes to: (1) the choice of comparing the suggested office layout alternatives using three different technique that prosper the overall result of the study, (2) the choice of demonstrating a methodology that prevent the confusion in the judgments, and (3) the choice of using not only quantitative but also qualitative criteria affecting the office layout configurations.

According to AHP method, the most essential criteria are chosen as position of materials. Analyzing the layout design of an office by using AHP method and comparing it with ELECTRE and permutation methods, the best ergonomic layout design is chosen as office C among three office alternatives. The ranking order of alternatives are concluded as office C, office B, and office A, respectively. While comparing it with the result of ELECTRE method, it is concluded that ELECTRE method is inefficient in this case because the results came out to be the same for all alternatives. Then, permutation method is applied as a solution to the problem. All in all, calculation results of the permutation method showed that office C is the best alternative which has the highest ranking value with 1.546. Thus, permutation method gives the same results that were ascertained in AHP. In future studies, the article can be expanded by working with different MCDM methods and the advantages of the new designs can be discussed more clearly. These proposed methods give a relatively good solution from the existing office alternatives. Thus, numerous office alternatives can be considered, and they can be focused on improving the alternatives.

Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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